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**OPERATING MANUAL
for
DATRON MODEL 1041/51
DIGITAL VOLTMETER**

METEOR CLOSE

NORWICH AIRPORT INDUSTRIAL ESTATE NORWICH NR6 6HQ ENGLAND



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OPERATING MANUAL
for
DATRON MODEL 1041/51
DIGITAL VOLTMETER

(FOR CALIBRATION &
MAINTENANCE PROCEDURES
REFER TO SERVICING MANUALS)

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NR 6 6TB

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SECTION 1

INSTALLATION

1.1 UNPACKING AND INSPECTION

Note:

SHOULD YOUR INSTRUMENT HAVE BEEN SUBJECTED TO EXCESSIVE MISHANDLING IN TRANSIT THE FACT WILL PROBABLY BE VISIBLE AS EXTERNAL DAMAGE TO THE SHIPPING CARTON. UNPACK THE INSTRUMENT AND CHECK FOR EXTERNAL DAMAGE TO CASE, PUSHBUTTONS, TERMINALS ETC. IF ANY DAMAGE IS FOUND, NOTIFY THE CARRIER IMMEDIATELY.

Every care is taken in the choice of packaging materials to ensure that your new instrument will reach you in a perfect condition. Our packaging and protection is adequate to cater for all the normal hazards of road or rail transit. Special export packaging is provided for overseas orders.

1.2 INSTALLATION

The instrument is housed in a robust, heavy-gauge aluminium case so designed to withstand the rough knocks of industrial usage. A detachable supply lead, comprising two metres of 3-core P.V.C. sheath cable permanently moulded to a fully-shrouded 3-pin cable socket, fits at the rear of the instrument and should be pushed firmly home. Connect the supply lead to a 3-pin plug (fused 1 amp), ensure that the instrument case is earthed via the Yellow/Green earthing wire.

1.2.1. Voltage Tappings

The instrument is packed ready for use with 205V to 255V, 48 to 440 Hz supplies, unless otherwise specified at the time of ordering. For operation from supplies in the range 105V to 127V, 48 to 440 Hz, it is necessary to alter the connections to the primary windings of the mains transformer. Remove the top cover and note the tags mounted on the printed circuit board adjacent to the mains transformer. For 205V to 255V operation the two primary windings are series connected by linking the 'start' (Red) of one winding to the 'finish' (Brown) of the other. Remove this link and reconnect the two windings in parallel as indicated in Fig. 1:1.

FIG 1:1 Mains transformer tappings

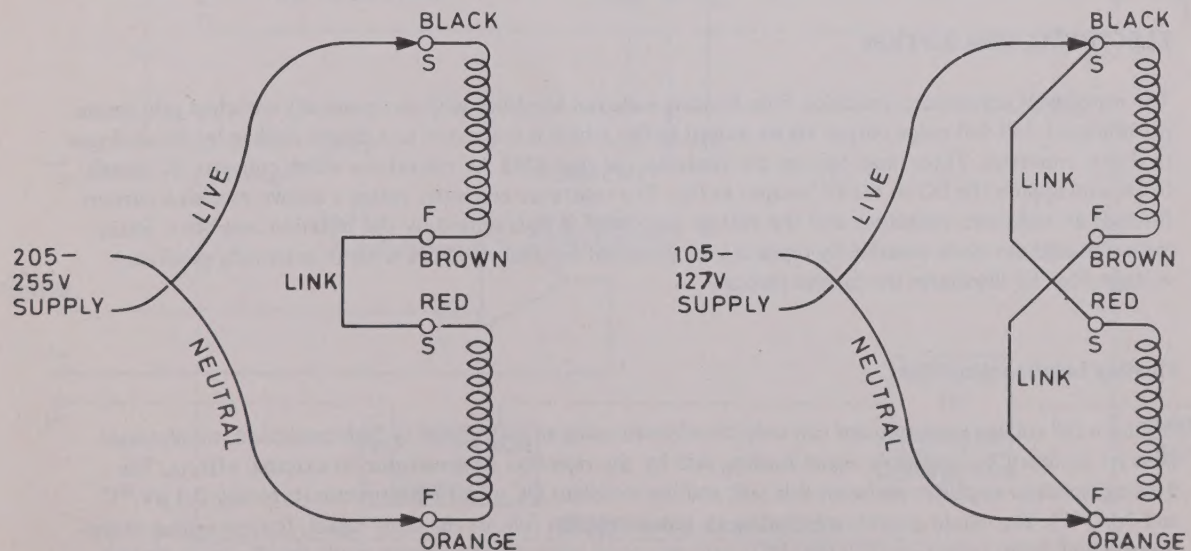


Fig 1:1

Mains Transformer Tappings

SECTION 2

GENERAL DESCRIPTION AND SPECIFICATION

2.1 FEATURES

This Multi-function digital voltmeter is a high precision measuring instrument featuring exceptionally high stability and full systems capability. The main frame, providing full D.C. measurement capability, can accept one of two available true RMS AC converters and a 4-wire resistance measurement converter providing an economical solution to most high precision measurement problems.

2.1.1. Options

- 01 Very high precision 6 range true R.M.S. converter.
- 11 Medium accuracy 4 range true R.M.S. converter.
- 02 Resistance converter providing guarded 4-wire measurements from $.001\Omega$ resolution to $19.999M\Omega$. (1041 only).
- 03 Resistance converter providing guarded 4-wire measurements from $.001\Omega$ resolution to $19.9999M\Omega$. (1051 only).
- P01 Electrically isolated remote programming.
- B01 Electrically isolated BCD output. (1041 only).
- B02 Electrically isolated 3-state BCD output. (1041 only).
- B04 Electrically isolated 3-state BCD output. (1051 only).
- R01 Rear input via a 7-way connector wired in parallel with the front panel terminals.
- R02 External reference, 1V range, a 4-wire reference input with connector mounted on the rear panel to provide ratio measurement capability. (1041 only).
- R03 External reference, 1V range, a 4-wire 4 quadrant reference input with connector mounted on the rear panel to provide ratio measurement capability. (1051 only).
- R05 As option R02 except external reference range is 10V and 100V. (1041 only).
- R06 As option R03 except external reference range is 10V and 100V. (1051 only).
- A01 Analogue output.

2.2 ELECTRICAL DESCRIPTION

The instrument comprises a precision fully floating isolation amplifier with electronically switched gain ranges providing a 1 volt full range output via its output buffer which is converted to a digital reading by the analogue to digital converter. Three main options are available, the true RMS AC converters which converts AC signals to DC and applies the DC to the DC output buffer. The resistance converter passes a known precision current through an unknown resistance and the voltage generated is thus sensed by the isolation amplifier. Ratio measurements are made possible by replacing the precision internal reference with an externally generated voltage. Fig. 2.1 illustrates the various sections.

2.2.1 Floating Isolation Amplifier

Accurate DC voltage measurement can only be achieved using an instrument of high resolution, which maintains its accuracy by negligible signal loading and by the rejection of errors due to external effects. The floating isolation amplifier performs this task and has excellent DC offset performance (typically $0.2 \mu V/^{\circ}C$ and $3pA/^{\circ}C$). The whole amplifier, including its power supplies follows the input signal, thus providing exceptionally high input impedance ($10,000 M\Omega$) and very good rejection of common mode signals due to its high common mode input impedance.

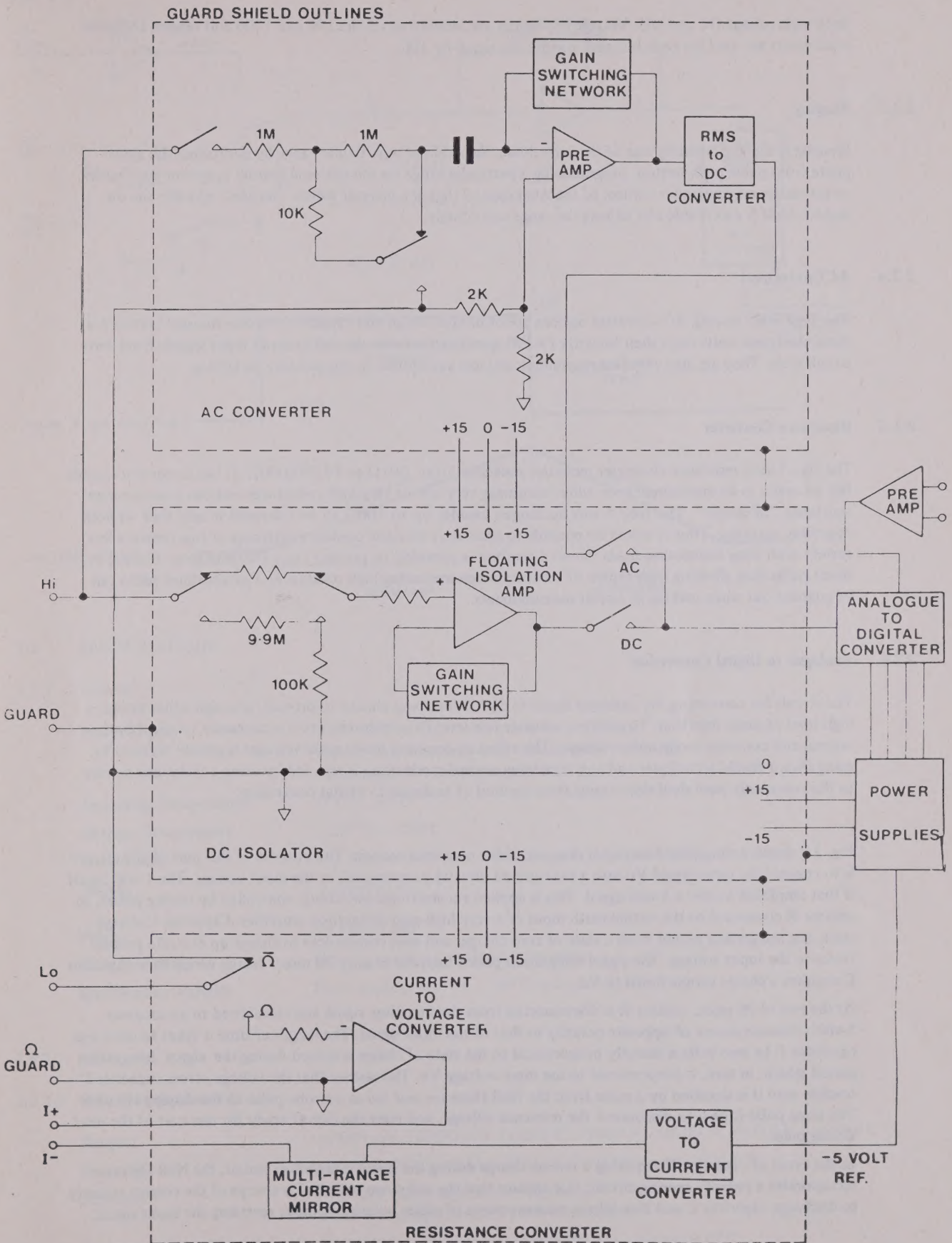


FIG. 2:1 Simplified Block Diagram

2.2.2 Input Attenuators

Both high voltage DC and high Voltage AC signals are attenuated on the 100 and 1000 volt ranges. Different attenuators are used for each but each divides the signal by 100.

2.2.3 Ranging

Ranging is accomplished by one of three methods. Selection of a particular range by depressing the appropriate front panel push button, programming a particular range via the optional remote programming facility, or automatic ranging under control of the Analogue to Digital converter which “decides” whether the displayed result is acceptable and adjusts the range accordingly.

2.2.4 AC Converters

The True RMS sensing AC converter options are of unique design and capability. Unlike thermal converters these electronic units meet their linearity (% FS) specifications over the full range of input signals from zero to full scale. They are also very fast responding and less susceptible to temperature variations.

2.2.5 Resistance Converter

The true 4-wire resistance converter measures resistance from $.001\Omega$ to $19,999,000\Omega$. It has features to enable full accuracy to be maintained even when measuring very low or very high resistances and can even measure resistance “in circuit”. The true 4-wire technique enables up to 100Ω to be tolerated in any lead without degrading accuracy. Thus it would be possible to *accurately* measure contact resistances or low resistors in a system with long connection leads. Ohms Guarding is provided to prevent error currents from flowing in shunt paths thus allowing high orders of accuracy when measuring high resistances. Certain shunt paths can be guarded out when making in circuit measurements.

2.2.6 Analogue to Digital Conversion

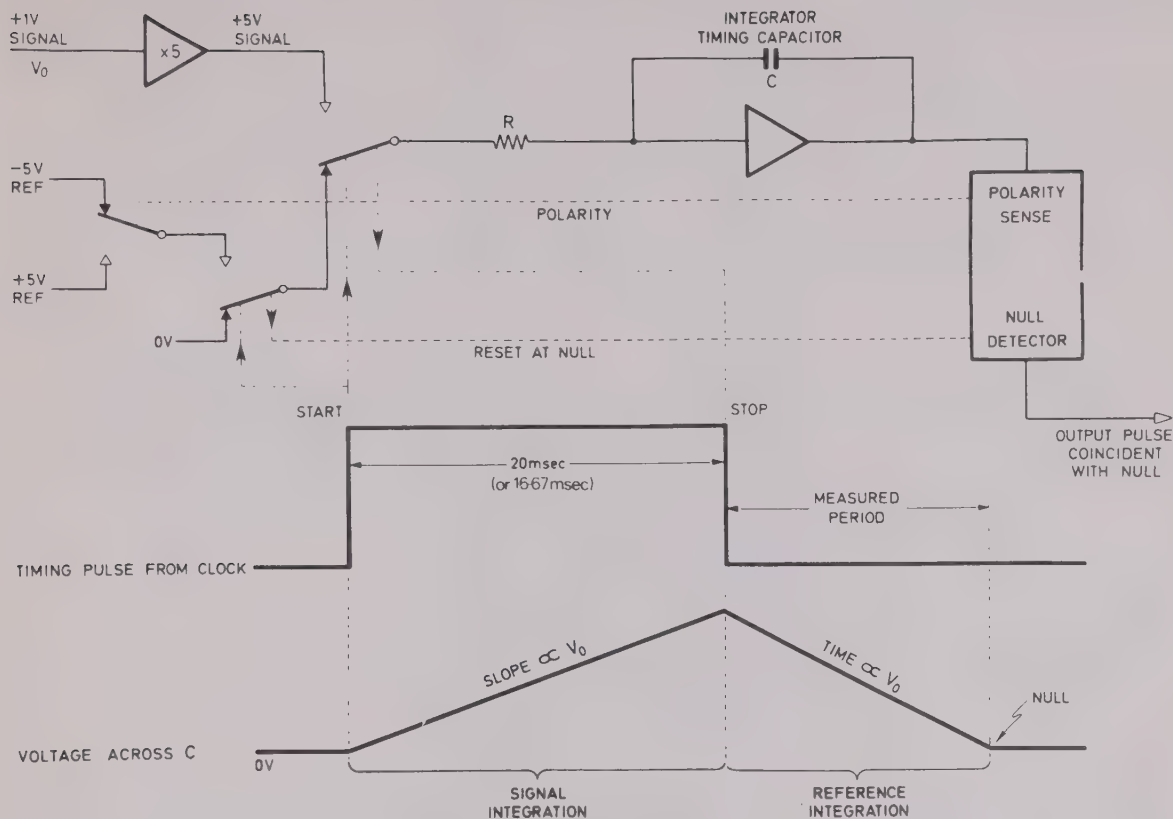
The circuit for converting the analogue signal to digital form was chosen to provide, amongst other things, a high level of noise rejection. To perform accurate low level DC measurements it is necessary to reject both normal and common mode noise voltages. The effect of common mode noise voltages is greatly reduced by using Guard Shield techniques and any remaining normal mode noise is rejected by using a technique similar to the commonly used dual slope integration method of analogue to digital conversion.

Fig. 2.2 shows a simplified functional diagram of the converter section. The purpose of this part of the circuit is to convert the input signal V_o into a time-period directly proportional to the input voltage. The 1-volt signal is first amplified to give a 5-volt signal. This is applied via electronic switching, controlled by timing pulses, to resistor R connected to the virtual-earth input of a very high-gain integration amplifier. Capacitor C always starts the integration period from a state of zero charge, and now commences to charge up at a rate proportional to the input voltage. The signal integration period lasts for exactly 20 msec, during which time capacitor C acquires a charge proportional to V_o .

At the end of 20 msec, resistor R is disconnected from the incoming signal and transferred to an accurate 5-volt reference source of opposite polarity to that of the input signal. The length of time it takes to discharge capacitor C to zero volts is directly proportional to the state of charge acquired during the signal integration period which, in turn, is proportional to the input voltage V_o . The instant that the voltage across capacitor C reaches zero it is signalled by a pulse from the Null Detector and fed as a strobe pulse to the display circuitry. The same pulse is used to disconnect the reference voltage, and reset the circuit ready for the start of the next timing pulse.

In the event of capacitor C acquiring a reverse charge during the signal integration period, the Null Detector incorporates a polarity-sensing circuit; this ensures that the reference potential is always of the correct polarity to discharge capacitor C and thus allows measurements of either polarity without reversing the input signal.

FIG. 2:2



2.3 SPECIFICATIONS

2.3.1 General

Power Supply

205 – 255 or 105 – 127 volts, 48 – 440 Hz.
Specify line frequency and voltage when ordering.
Consumption is approximately 12 VA.

Operating Temperature

0°C to 50°C

Storage Temperature

–25°C to +70°C

Dimensions

H = 90 mm (3.5"), W = 440 mm (17.25"), D = 343 mm (13.5")

Weight

5.5 kg (12 lbs)

Weight

5.5 kg (12 lbs)

Rack Mounting

"Ears" mounted on side of instrument

Specification Validity

For 6 months over 18 – 28°C or as describe^d

2.3.2 1041 only

2.3.2.1 D.C. Voltage Measurement

Ranges

10.000 mV, 100.00 mV, 1.0000 V, 10.000 V, 100.00 V, 1000.0 V Automatic.

Overrange

100% i.e. 19999 full scale (FS) on all ranges except 1000.0 V.

Accuracy

After mV offset adjustment, all ranges.
 $\pm 0.01\%$ reading $\pm 0.005\%$ FS ± 1 microvolt.

Temperature Coefficient

$\pm 1/10$ [of above accuracy rating] /°C ± 0.2 microvolts/°C.

Stability

After six months use better than above accuracy rating per year plus microvolt offset of typically less than 2 microvolts per month.

Common Mode Rejection (1 k Ω Source Unbalance)	DC > 140 dB	
	AC > 80 dB + SERIES MODE up to 174 dB. (1 Hz to 60 Hz)	
Series Mode Rejection	FILTER OUT	> 20 dB @ 50 Hz increasing at 30 dB per octave + NOTCH REJECTION
	FILTER IN	> 57 dB @ 50 Hz increasing at 18 dB per octave + NOTCH REJECTION
	NOTCH REJECTION	> 50 dB @ Line Frequency $\pm$ 0.15% 36 dB @ Line Frequency $\pm$ 1%
	FILTER OUT – (OPTION F01)	NOTCH REJECTION alone.
	FILTER OUT FILTER OUT (F01) FILTER IN	78 milliseconds) ADD 30 milliseconds 5 milliseconds) if changing into or out 350 milliseconds) of 100 V, 1 kV ranges.
Settling Time (to 0.01%)		
Read Rate	Maximum independent reading rate with a nominal full range signal.	
	FILTER OUT	10/second
	FILTER OUT (F01)	20/second
	FILTER IN	2.5/second
Maximum Input Voltage (Without damage)	Signal Hi to Signal Lo	1000 V r.m.s. (Any range)
	Signal Lo to Guard	250 V peak
	Guard to Earth (Case)	500 V peak
	Any Terminal to any - other in “ohms”	250 V DC or r.m.s.

Note: The small slide switches near the terminals connect OHMS GUARD [= Lo in voltage measurement] to GUARD or I+ to Hi and I– to Lo. Therefore if a voltage is applied across these connected (via the switches) terminals, then **SEVERE DAMAGE COULD OCCUR** necessitating the replacement of the switches and the input terminal PCB.

Input Resistance (Rin)	10 mV to 10 V ranges (up to 20 V)	Rin > 10,000 M Ω
	100 V and 1,000 V ranges	Rin = 10 M Ω $\pm$ 0.1%
Input Current	<50 pA drifting at typically < 3 pA/°C	
Auto Range	Ranges up at 200% of Nominal Range	
	Ranges down at 10% of Nominal Range	
	Range Speed (Typical):–	
	FILTER OUT UP	160 milliseconds per Range
	FILTER OUT DOWN	120 milliseconds per Range
	FILTER IN UP	550 milliseconds per Range
	FILTER IN DOWN	500 milliseconds per Range

2.3.2.2 AC Voltage Measurement

Option 11

Ranges	1.0000 Volts, 10.000 Volts, 100.00 Volts, 1000.0 Volts, + Auto.	
Overrange	100% i.e. 19999 FS except 1000V.	
Accuracy	6 months duration 18 – 28°C < 2 x 10 ⁷ V.Hz [Signal > .02% FS]	
	*40 Hz – 5 kHz	± 0.1% reading ± 0.02% FS
	5 kHz – 20 kHz	± 0.2% reading ± 0.05% FS
	20 kHz – 100 kHz	± 0.3% reading ± 0.1% FS

Option 01

Ranges	10.000 mV, 100.00 mV, 1.0000 Volts, 10.000 Volts, 100.00 Volts, 1000.0 Volts + Auto
Overrange	100% i.e. 19999 FS except 1000 Volts

Accuracy	6 months duration 18–28°C < 2 × 10 ⁷ V.Hz. [Signal > 300μV, > .02% FS] 100 mV – 1000 Volt ranges:– *40 Hz – 5 kHz ± 0.03% reading ± 0.01% FS 5 kHz – 20 kHz ± 0.06% reading ± 0.02% FS 20 kHz – 100 kHz ± 0.1% reading ± 0.05% FS add 1 ppm per volt above 300 Volts – Bandwidth approximately 5 MHz. 10 mV range [signal > 300μV] *40 Hz – 5 kHz ± 0.1% reading ± 0.05% FS 5 kHz – 20 kHz ± 0.2% reading ± 0.05% FS Bandwidth approximately 500 kHz.
-----------------	---

Both AC Converters

Where * noted above read 250 Hz instead of 40 Hz if Filter is Out [360 Hz if Option F01 is fitted].

Temperature Coefficient	< 1/10 [above accuracy rating]/°C
Common Mode Rejection	1 kΩ unbalance in Hi > 120 dB @ DC – 60 Hz. 1 kΩ unbalance in Lo > 80 dB @ DC – 60 Hz.
Settling Time	(To 0.1% of final value attacking) FILTER OUT < 80 msec. FILTER IN < 350 msec.
Settling Time	(To 0.1% of range, decaying) FILTER OUT < 150 msec. FILTER IN < 500 msec.
Settling Time	(From severe overload). Up to Double the above times.
Settling Time	(From DC Bias Input). Time Constant 2.2 Secs.
Maximum Input Voltage	1500 V peak on any range. < 2 × 10 ⁷ V.Hz. Measures AC component with up to 1000 V DC bias on any range.
Conversion Type	True r.m.s. (AC coupled).
Input Impedance	1 MΩ shunted by 75 pF (150 pF with rear input).

2.3.2.3 Resistance Measurement Option 02

Ranges	10.000 Ohms, 100.00 Ohms, 1.0000 kΩ, 10.000 kΩ, 100.00 kΩ, 1000.0 kΩ, 10,000 kΩ, + Auto
Overrange	100% on all ranges.
Accuracy	6 months duration 18–28°C. 10 Ohms range ± 0.01% reading ± 0.01% FS. 100 Ohms to 100 kΩ ± 0.01% reading ± 0.005% FS. 1 Megohm ± 0.02% reading ± 0.005% FS 10 Megohm ± 0.1% reading ± 0.005% FS
Temperature Coefficient	1/10 [above accuracy rating] °C
Type	True 4-wire with active guard (can be switched to 2-wire on front panel). Ratio measurement technique not dependant on internal reference voltage.
Current Through Unknown	10Ω and 100Ω ranges 10.000 milliamps 1 kΩ 1.0000 milliamps 10 kΩ 100.00 microamps 100 kΩ 10.000 microamps 1 MΩ 1.0000 microamps 10 MΩ 100.0 nanoamps

Lead Resistance	Up to 100Ω may be tolerated in any or all the leads on any range without degrading the accuracy. Resistances up to 100 kΩ may be tolerated on the higher ranges provided that the lead resistance does not drop more than 1 Volt across it due to the measurement current in the above table.	
Ohms Guard		
Drive Capability	I+ or Lo to OHMS GUARD	250 Ohms min.
Guarding Capability	Down to 20% of range or limited by drive capability [i.e. minimum resistance between OHMS GUARD and SIGNAL Lo] for less than 0.01% accuracy degradation. Lower percentage of range will degrade accuracy as:–	
	$\frac{\text{FULL RANGE}}{\text{GUARDED RESISTANCE}}$	x 0.002% reading.
Response Times	Depends on external capacitance and guarding and shielding techniques used. Generally up to 100 kΩ response is as DC. Higher resistances may take longer to settle. OHMS GUARD may be used to guard out stray capacitance.	

2.3.2.4 External Reference (Ratio)

Capability	DC/DC, AC/DC, OHMS/DC.	
Type	4-wire positive reference	
Temperature Coefficient	1/10th accuracy rating/°C.	
Common Mode Rejection	> 60 dB DC – 60 Hz	
Series Mode Rejection	36 dB @ 50 Hz increasing at 40 dB per decade.	
Response Time	1 sec to .01% final value.	
Option R02		
Ranges	External Reference Input + 0.2 V to + 1.2 V Signal Input As function and range	
Accuracy	$\pm X\% \text{ reading} \pm Y \frac{1}{\text{ref}} \% \text{ FS}$ X = appropriate % reading spec. for signal input range and function selected. Y = appropriate % full scale spec. for signal input range and function selected. e.g. for DC signal input accuracy is:– $\pm 0.01\% \text{ reading} \pm 0.005 \frac{1}{\text{ref}} \% \text{ FS}$	
Input Resistance	1000 MΩ differential 100 MΩ ref. Hi to Signal Lo.	
Common Mode Voltage (w.r.t. Signal Lo)	± 10 V max	
Maximum Reference Input (without damage).	250 V DC or r.m.s.	
Option R05		
Ranges	External Reference Input: + 2 V to + 12 V (10 V range) + 20 V to + 120 V (100 V range) Signal Input: As function and range.	
Accuracy	$\pm X \text{ reading} \pm Y \frac{10V}{\text{ref}} \% \text{ FS (10 V range)}$ $\pm X \text{ reading} \pm Y \frac{100V}{\text{ref}} \% \text{ FS (100 V range)}$ Where X and Y are as Option R02.	

Input Resistance	1 M Ω $\pm$.5% (10 V range) 10 M Ω $\pm$.5% (100 V range)
Common Mode Voltage (w.r.t. Signal Lo)	$\pm$ 100 V max. (10 V range) $\pm$ 500 V max. (100 V range)
Maximum Reference Input (without damage)	$\pm$ 500 V DC or peak

2.3.2.5 Analogue Output

Range	0 $\pm$ 2 Volts, 1 Volt per nominal Full Range.
Output Resistance	< 10 Ohms
Output Current	Up to 5 milliamps
Protection	Fuse protected against accidental overload in both Output Hi and Output Lo leads.

2.3.2.6 BCD Output

Option B01 gives reading, range and function 1.2.4.8. +ve true TTL compatible code. External Hold and Read Command facilities are provided together with signal integrate and print command output flags. FAN OUT : 2 TTL LOADS, FAN IN: 1.

Option B02 is as B01 but with the added facility of turning all the outputs into a high impedance condition (i.e. “OFF”) and disabling all inputs.

Both options are electrically isolated from the signal input terminals.

2.3.2.7 Programming

Option P01 gives the capability of fully programming the instrument with TTL signals via a rear panel mounted connector. All ranges and functions may be programmed and all front panel controls disabled with the exception of the two terminal slide switches. Fan in 1 TTL load maximum.

2.3.3 1051 only

2.3.3.1 DC Voltage Measurement

Ranges	100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 1000.00 V, + Auto 10.0000 mV, (Manual only).	
Overrange	100% i.e. 199999 full scale (FS) on all ranges except 1000.00 V.	
Accuracy (6 months)	After mV offset adjustment, all ranges. $\pm$ 0.005% reading $\pm$ 0.0005% FS $\pm$ 1 microvolt.	
Temperature Coefficient	$\pm$ 1/10 [of above accuracy rating] / $^{\circ}$ C $\pm$ 0.2 microvolts/ $^{\circ}$ C.	
Stability	After six months use better than 50 ppm per year.	
Short Term Accuracy	As above but .002% reading 24 hrs 22 – 24 $^{\circ}$ C .004% reading 90 days 18 – 28 $^{\circ}$ C	
Common Mode Rejection (1 kΩ Source Unbalance)	DC > 140 dB AC > 80 dB + SERIES MODE up to 180 dB	
Series Mode Rejection	FILTER OUT (100 mV – 1 kV)	> 70 dB notch at line frequency and multiples of line frequency.
	FILTER IN (100 mV – 1 kV)	> Above notch + 36 dB at 50 Hz increasing at 40 dB per decade.
	10 mV Range	> Above + 46 dB at 50 Hz increasing at 20 dB per decade.
Settling Time (to .001%)	FILTER OUT	< 5 milliseconds
	FILTER IN	< 350 milliseconds
	10 mV range only	approx. 10 seconds

Read Rate	Maximum independent reading rate with a nominal full range signal.	
	FILTER OUT	20/second
	FILTER IN	2.5/second
Maximum Input Voltage (without damage)	Signal Hi to Signal Lo	1000 V r.m.s. (Any Range)
	Signal Lo to Guard	250 V peak
	Guard to Earth (Case)	500 V peak
	Any Terminal to any other in "ohms"	250 V DC or r.m.s.

Note: The small slide switches near the terminals connect OHMS GUARD [= Lo in voltage measurement] to GUARD or I+ to Hi and I– to Lo. Therefore if a voltage is applied across these connected (via the switches) terminals, then **SEVERE DAMAGE COULD OCCUR** necessitating the replacement of the switches and the input terminal PCB.

Input Resistance (Rin)	10 mV to 10 V ranges (up to 20 V)	Rin > 10,000 MΩ
	100 V and 1,000 V ranges	Rin = 10 MΩ ± 0.1%
Input Current	< 50 pA drifting at typically 3 pA/°C	
Auto Range	Ranges up at 200% of Nominal Range Ranges down at 10% of Nominal Range Range Speed (Typical):– FILTER OUT UP 70 milliseconds per Range FILTER OUT DOWN 30 milliseconds per Range FILTER IN UP 460 milliseconds per Range FILTER IN DOWN 420 milliseconds per Range	

2.3.3.2 AC Voltage Measurement

Option 1.1

Ranges	1.00000 Volts, 10.0000 Volts, 100.000 Volts, 1000.00 Volts, + Auto
Overrange	100% i.e. 199999 FS except 1000 V
Accuracy	6 months duration 18 – 28°C, < 2 x 10 ⁷ V.Hz, SIG > 0.02% FS *40 Hz – 5 kHz ± 0.1% reading ± 0.02% FS 5 kHz – 20 kHz ± 0.2% reading ± 0.03% FS 20 kHz – 100 kHz ± 0.3% reading ± 0.1% FS

Option 0.1

Ranges	100.000 mV, 1.00000 Volts, 10.0000 Volts, 100.000 Volts, 1000.00 Volts + Auto
Overrange	100% i.e. 199999 FS except 1000 Volts
Accuracy	6 months duration 18 – 28°C, < 2 x 10 ⁷ V.Hz [Signal > 300μV, > .02% FS] 100 mV – 1000 Volt ranges:– *40 Hz – 5 kHz ± 0.03% reading ± 0.01% FS 5 kHz – 20 kHz ± 0.06% reading ± 0.02% FS 20 kHz – 100 kHz ± 0.1% reading ± 0.05% FS add 1 ppm per volt above 300 Volts – Bandwidth approximately 5 MHz.

Both AC Converters

Where * noted above read 360 Hz instead of 40 Hz if Filter is Out.

Temperature Coefficient	< 1/10 [above accuracy rating]/°C	
Common Mode Rejection	1 kΩ unbalance in Hi	> 120 dB @ DC – 60 Hz
	1 kΩ unbalance in Lo	> 80 dB @ DC – 60 Hz
Settling Time	(To 0.1% of final value attacking)	
	FILTER OUT	< 80 msec.
	FILTER IN	< 350 msec.

Settling Time	(To 0.1% of range, decaying) FILTER OUT < 150 msec. FILTER IN < 500 msec.
Settling Time	(From severe overload) Up to Double the above times
Settling Time	(From DC Bias Input) Time Constant 2.2 Secs
Maximum Input Voltage	1500 V peak on any range. (Filter must be selected above 500 V r.m.s.) < 2×10^7 V.Hz Measures AC component with up to 1000 V DC bias on any range.
Conversion Type	True r.m.s. (AC coupled)
Input Impedance	1 M Ω shunted by 75 pF (150 pF with rear input)

2.3.3.3 Resistance Measurement Option 03

Ranges	100.000 Ohms, 1.00000 k Ω , 10.0000 k Ω , 100.000 k Ω , 1000.00 k Ω , 10.0000 M Ω , + Auto	
Overrange	100% on all ranges	
Accuracy	6 months duration 18 – 28°C 100 Ohms to 100 k Ω $\pm$ 0.005% reading $\pm$ 0.001% FS 1 Megohm $\pm$ 0.02% reading $\pm$ 0.001% FS 10 Megohm $\pm$ 0.1% reading $\pm$ 0.001% FS	
Temperature Coefficient	1/10 [above accuracy rating]/°C	
Type	True 4-wire with active guard (can be switched to 2-wire on front panel). Ratio measurement technique not dependant on internal reference voltage.	
Short Term Accuracy	100 Ohms to 100 k Ω as above but .002% reading 24 hrs 22 – 24°C .004% reading 90 days 18 – 28°C	
Current Through Unknown	100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω	10.000 milliamps 1.0000 milliamps 100.00 microamps 10.000 microamps 1.0000 microamps 100.0 nanoamps
Lead Resistance	Up to 100 Ω may be tolerated in any of all the leads on any range without degrading the accuracy. Resistances up to 100 k Ω may be tolerated on the higher ranges provided that the lead resistance does not drop more than 1 Volt across it due to the measurement current in the above table.	
Ohms Guard		
Drive Capability	I+ or Lo to OHMS GUARD 250 Ohms min.	
Guarding Capability	Down to 20% of range or limited by drive capability [i.e. minimum resistance between OHMS GUARD and SIGNAL Lo] for less than 0.01% accuracy degradation. Lower percentage of range will degrade accuracy as:–	
	$\frac{\text{FULL RANGE}}{\text{GUARDED RESISTANCE}} \times 0.002\% \text{ reading}$	
Response Times	Depends on external capacitance and guarding and shielding techniques used. Generally up to 100 k Ω response is as DC. Higher resistances may take longer to settle. OHMS GUARD may be used to guard out stray capacitance.	

2.3.3.4 External Reference (Ratio)

Capability	DC/DC, AC/DC, OHMS/DC.
Type	4-wire, 4 quadrant
Temperature Coefficient	1/10th accuracy rating/°C
Common Mode Rejection	> 60 dB DC – 60 Hz
Series Mode Rejection	36 dB @ 50 Hz increasing at 40 dB per decade.
Response Time	1 sec to .01% final value

Option R03

Ranges	External Reference Input $\pm 0.3\text{V}$ to $\pm 2\text{V}$ Signal Input As function and range
Accuracy (6 months)	$\pm X\%$ reading $\pm Y \cdot \frac{2}{\text{ref}}$ % FS Where X = appropriate % reading spec. for Signal input range and function selected. Y = appropriate % full scale spec. for signal input range and function selected. e.g. for DC Signal input accuracy is:– $\pm 0.005\%$ reading $\pm 0.0005 \frac{2}{\text{ref}}$ % FS

Input Resistance	1000 M Ω differential 100 M Ω ref. Hi to Signal Lo
------------------	---

Common Mode Voltage (w.r.t. Signal Lo)	$\pm 10\text{V}$ Max
---	----------------------

Option R06

Ranges	External Reference Input $\pm 3\text{V}$ to $\pm 20\text{V}$ (10 V range) $\pm 30\text{V}$ to $\pm 200\text{V}$ (100 V range) Signal Input As function and range
Accuracy (6 months)	$\pm X\%$ reading $\pm Y \cdot \frac{40}{\text{ref}}$ % FS (10 V range) $\pm X\%$ reading $\pm Y \cdot \frac{400}{\text{ref}}$ % FS (100 V range)

Where X and Y are as Option R03.

Input Resistance	1 M Ω $\pm .1\%$ (10 V range) 10 M Ω $\pm .1\%$ (100 V range)
------------------	--

Common Mode Voltage (w.r.t. Signal Lo)	$\pm 100\text{V}$ max. (10 V range) $\pm 500\text{V}$ max. (100 V range)
---	---

Maximum Reference Input (without damage)	$\pm 500\text{V}$ DC or peak
---	------------------------------

2.3.3.5 Analogue Output

Accuracy	As normal specifications $\pm .01\%$ FS
Range	0 ± 2 Volts, 1 Volt per nominal Full Range
Output Resistance	< 10 Ohms
Output Current	Up to 5 milliamps
Protection	Fuse protected against accidental overload in both Output Hi and Output Lo leads.

2.3.3.6 BCD Output

Option B04 gives reading, range and function 1.2.4.8. +ve trueTTL compatible code. External Hold and Read Command facilities are provided together with signal integrate and print command output flags. FAN OUT: 2TTL LOADS, FAN IN: 1.

Provided as standard is the facility of turning all the outputs into a high impedance condition (i.e. “OFF”) and disabling all inputs.

Option is electrically isolated from the signal input terminals and referred to power ground via a 100 k Ω resistor.

2.3.3.7 Programming

Option P01 gives the capability of fully programming the instrument with TTL or CMOS signals via a rear panel mounted connector. All ranges and functions may be programmed and all front panel controls disabled with the exception of the two terminal slide switches. Fan in 1 TTL load maximum.

2.3.4 SPECIFICATION VERIFICATION

A checking routine to ensure that the instrument is working within its specified accuracy is given in Section 6. SPECIFICATION VERIFICATION. The checking procedures given are suitable for incoming inspection purposes, or for use as a periodic check of instrument calibration.

SECTION 3

CONTROLS AND OPERATION

3.1 INPUT CONNECTIONS

Six signal input terminals are located on the front panel marked respectively Hi, Lo, GUARD, I+ (Ohms current positive), I- (Ohms current negative), and Ohms Guard. They are Red, Black, White, Brown, Blue and Yellow respectively. The terminals are mounted on a standard 0.75 inch (19 mm) spacing and connection may be made using 4 mm single or double banana plugs.

In order to minimise thermal E.M.F., copper wire should be used connecting the instrument and preferably passed through the side entry holes of the Hi and Lo terminals.

Two slide switches are mounted adjacent to the terminals. The 2-wire 4-wire switch connects Hi to I+ and Lo to I- in the 2-wire position to facilitate general purpose medium accuracy resistance measurements and the GUARD – LOCAL/REMOTE switch connects the Guard terminal internally to the Lo terminal (to OHMS Guard when in OHMS) when in its LOCAL position.

Ohms GUARD is internally connected to Lo in voltage measurement and thus on no account may power be applied between the two. For the same reason on no account may power be applied across the shorting action of the slide switches when they are closed, i.e. between Hi and I+, Lo and I- and Lo and GUARD.

Note:

The following input voltages must not be exceeded under any circumstances:—

Hi to Lo	1000 Volts DC or r.m.s. or 1500 Volts peak
Lo to GUARD	250 Volts peak
GUARD to EARTH	500 Volts peak
I+ or I- to Lo	250 Volts DC or r.m.s.
I+ or I- to Ω GUARD	250 Volts DC or r.m.s.
I+ to I-	250 Volts DC or r.m.s.

Full details of the recommended methods of making connection between the input terminals and the circuit under test are given in Section 3.3.1.

3.2 PUSH BUTTONS

The push buttons are in four groups labelled RANGE, MODE, FUNCTION and CONTROL.

3.2.1 Control Group

POWER

A push button switch with alternate ON/OFF action is mounted in the centre of the front panel. It isolates the mains supply live from the instrument with the exception of the mains fuse, socket and filter which remain live unless the supply lead is disconnected.

HOLD

The instrument normally free runs taking about 3 readings per second but on depressing the HOLD button the internal command mechanism is disabled. Any conversion in progress is completed and displayed: the display being held until HOLD is released or a COMMAND initiated either via the BCD connector or the MANUAL push button.

MANUAL

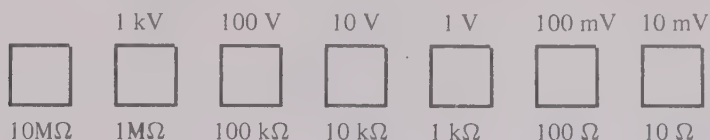
This is a momentary action button whose operation is only enabled when the HOLD button is depressed. A single reading is then indicated when the MANUAL button is pushed. Care should be taken since contact bounce can cause double commanding. If the instrument is in the Auto-range mode then upon receipt of a single manual command it will range, inhibiting the print command, until the correct range is reached. A print command is then generated and no more readings taken until MANUAL is again depressed.

PRINT INHIBIT

When this button is depressed the print command flag of the BCD output is held low to arrest any print action which is occurring. If option B02 or B04, with three state outputs, is fitted PRINT INHIBIT turns all the outputs into the "OFF" or high impedance state and disables the command control inputs.

3.2.2. Range Group

There are seven range buttons which are interlocked such that only one at a time can be depressed. The push buttons are marked from right to left: –



The corresponding full range displays are self-explanatory with the exception of 1 MΩ where the display is, in fact, 1000.0 kΩ. The 10 MΩ push button is only valid in OHMS, and on the 1041 10 MΩ is displayed as 10000 kΩ.

OVERRANGE is signified by a 1 being illuminated at the left of the normal display. 100% overrange permits a maximum display of 19999 except on the 1 kV range where it is limited by a maximum input voltage of 1000.0 Volts.

OVERLOAD results in blanking of the digits above 100% overrange. The function lights remain illuminated.

On 1051 the 10Ω range is unspecified and the 10 mV range is specified only on DC voltage and is not included in the AUTO mode.

3.2.3. Mode Group

AUTO

When AUTO is depressed the instrument will take readings and automatically select the range which gives the most accurate display. It ranges up to a less sensitive range if a reading results in OVERLOAD and ranges down if the result is less than 10% of the nominal range. It automatically stops on the highest or lowest range applicable to the function selected. On releasing the AUTO button the instrument immediately returns to the range selected by the range buttons.

REMOTE

When the REMOTE button is depressed all the RANGE, FUNCTION and other MODE buttons are disabled. Remote programming is then enabled and a REMOTE output flag generated on the programming connector. Holding down the REMOTE line externally also performs the same function irrespective of where the button is.

FILTER

Depressing the FILTER button increases the series mode AC noise rejection when measuring DC volts or resistance and enables AC measurements to be made down to 40 Hz. It also slows down the response time and whilst the internal read rate remains the same Autoranging commands are internally delayed to allow for the increased settling time.

3.2.4. Function Group

The three functions AC, DC or OHMS are selected via the three interlocked function switches in a self explanatory manner. If all three buttons are released or if the instrument is in the REMOTE mode it assumes that DC has been selected. In instruments where the AC or OHMS options are not installed then the appropriate switch is mechanically prevented from being pushed in.

3.2.5. mV Offset

This is a screwdriver operated multi-turn preset control to enable the instrument to be adjusted for zero input signal applied to the 10 mV range. Its range is approximately ± 80 microvolts and it can then be used very effectively to compensate for external offsets as well as the instrument's own very low, long term zero drift.

3.2.6 Rear Panel Controls

POWER FUSE

The supply to the mains transformer primary windings is protected by a 100 mA rating 20 mm x 5 mm glass cartridge fuse of the type variously known as “delay”, “slow blow”, “time lag” or “anti-surge”. The fuse may be inspected and, if necessary, replaced by unscrewing the cap on the fuseholder located on the rear panel of the instrument.

Suitable replacement fuses are:—

Belling Lee	L2080/100
Radiospares	A/S Fuse 20 mm 100 mA
A.F. Bulgin	Type F286/100 mA

REFERENCE INT/EXT (OPTION)

This slide switch enables either internal or external reference if Option R02, R03, R05 or R06 (external reference or Ratio) is installed. A 5-pin socket allows application of external reference signals.

REAR INPUT (OPTION)

A 9-pin connector, connected in parallel to the input terminals, optionally allows the signal to be applied via the rear panel. THIS MEANS THAT IF HIGH VOLTAGE IS APPLIED TO ONE CONNECTOR THE OTHER COULD BE AT A DANGEROUS POTENTIAL.

ANALOGUE OUTPUT AND FUSES. (OPTION)

A 5-pin connector giving a 1V full range DC output per full range input. It is not isolated from the input terminals but fused in both High and Low lines with a fast action 15 mA fuse.

BCD OUTPUT (OPTION)

A 50-way AMPHENOL “BLUE RIBBON” connector providing TTL logic level codes for reading range and function.

PROGRAM (OPTION)

A 14-way AMPHENOL “BLUE RIBBON” connector enabling programming of all ranges and functions.

POWER SOCKET

A 3-pin CEE regulation 250 V, 6A power socket accepts the mating plug which is integrally moulded with the power lead.

3.3. OPERATION

Preliminary Checks

1. Check that the instrument is correctly adjusted for the mains supply to which it is to be connected. See Section 1.2.1.
Note: No fine tapping adjustments are required for voltages within each of the major ranges.
2. Connect the mains supply leads.
3. Switch on the supply and allow the equipment to stabilize.
4. Before commencing any further, read Section 2, Section 3.1 and 3.2 and in particular the Note in Section 1, page 1.

3.3.1 Common Mode and Guard

Common Mode Voltages are equally present on both terminals of the voltage source being measured and excessive levels, either AC or DC, can affect the measurement being made. However, sensible use of the GUARD terminal can reduce errors to a negligible level.

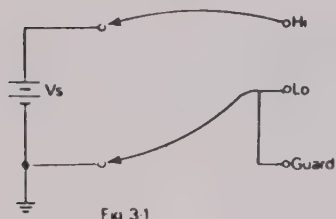


Fig 3-1

The disadvantage of the simple arrangement in Fig. 3.1 is that the connecting leads form a loop. If a stray alternating magnetic field from the mains transformer of a neighbouring instrument passes through the loop it will behave as a single turn secondary winding, and unwanted AC voltages will be induced into the measuring circuit.

The GUARD terminal should be used when the source to be measured presents an unbalanced impedance to the measuring terminals and Common Mode Voltages are present. In general, regardless how the Hi and Lo terminals are connected, the GUARD terminal should refer to the source of Common Mode Voltage as shown in Figs. 3.2, 3.3, 3.4 and 3.5.

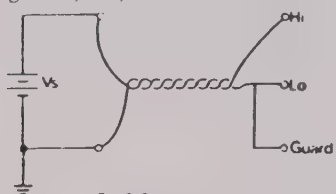


Fig 3-2

Fig. 3.2 is a better arrangement, where the twisted pair reduces the loop area and adjacent twists of the wires produce cancellation of any induced voltages.

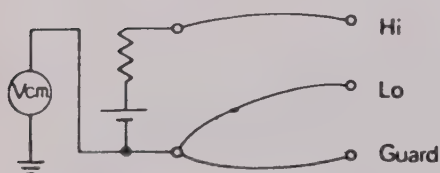


Fig 3-3

The simple case in Fig. 3.3 allows the GUARD to be connected remotely or at the terminals since in both cases it is to the source of Common Mode Voltages.

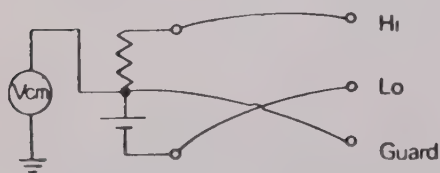


Fig 3-4

Fig 3.4 shows a case where the Common Mode Voltage is not present on the Lo measurement terminal and should therefore be connected remotely.

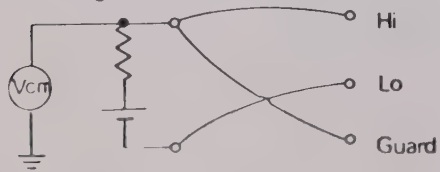


Fig 3-5

Fig 3.5 shows an extreme situation where all the unbalance to Common Mode Voltage is in the Lo lead and GUARD must therefore be connected to Hi.

The cases above show the connections made by use of individual wires, it is recommended, however that a screened twisted pair microphone cable be used with the GUARD terminal connected to the screen.

Table 3. below lists the recommended types.

TABLE 3.1

Manufacture	Type	pF/metre	Outside diameter
Suhner	G03939	65	4.6 mm
Suhner	CB04730	195	5.3 mm
Transradio	MC 02-A	115	4.4 mm
Transradio	MC 02-D	130	3.5 mm
B.I.C.C.	9442Y	120	5.7 mm

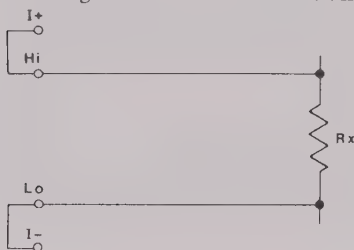
When making a particular measurement, choose the most suitable method of connection and check that it does not involve exceeding any of the input voltages listed under Section 3.1.

3.3.2 Special Notes — Thermal e.m.f.

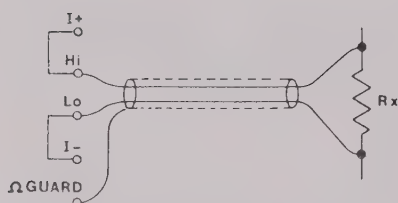
Where very low level measurements are being made, care must be taken to minimise and balance thermal e.m.f. generated in the leads. In general, the use of steel probes, croc-clips and all metals with the exception of copper is to be avoided.

3.3.3 Resistance Measurements

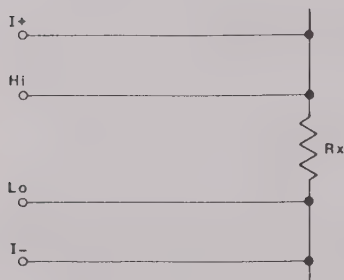
Resistances can be most simply measured by switching the front panel slide switch to “2-wire” thus connecting I+ to Hi and I− to Lo. The unknown resistor is then simply connected between Hi and Lo.



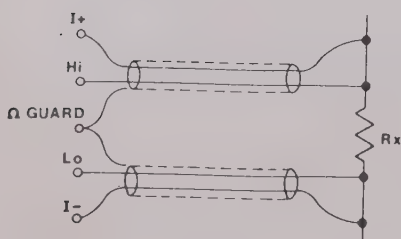
This system measures Rx but has the snag that lead resistances are in series with Rx and thus provide a measurement error. The leads are also unscreened and pick up considerable noise particularly where Rx is high.



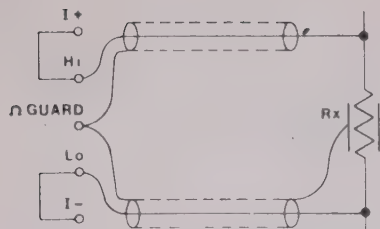
This system overcomes the noise problem described above but still may not be suitable for the accurate measurement of very low or very high resistances particularly when the leads are long. GUARD should be switched to LOCAL.



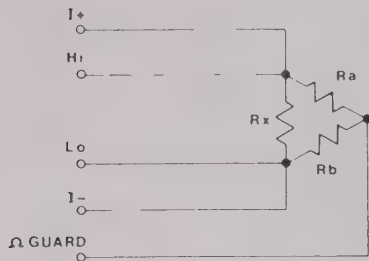
Any resistance in the leads in this system has no effect since, if in the current leads it does not effect the current through Rx and sense leads are very high impedance and not carrying current.



This method combines ideal screening with the 4-wire technique. It is also suitable for high resistances with long cables since the effects of leakage and capacitance between the wires is eliminated.



In this case a two-wire technique is used for very high resistance measurements and the OHMS GUARD connected to a guard screen wrapped around the resistor (or the case it is mounted in). Since $I+ = H_i$ and $I- = L_o$ two screened cables may be used, $I+$ with Ω Guard Screen, $I-$ with Guard Screen for optimum guarding.



This system shows how OHMS GUARD can be used to make "In-circuit" measurements. Provided R_a and R_b are no less than 250Ω or 20% of RANGE then the system measures R_x to full accuracy. It may of course be combined with the screening techniques above.

Additional shunt paths may also be connected to OHMS GUARD provided the parallel combination is no less than 250Ω or 20% of range.

SECTION 4

OPTIONAL REMOTE OPERATION

4.1 OPTION B01: PARALLEL BCD LOGIC OUTPUT (1041 only)

Option B01 enables full Binary Coded Decimal outputs describing Reading Range and Function to be obtained from a 50-way Amphenol blue ribbon connector (J5) mounted on the rear panel. The outputs are isolated from the signal input terminals and referred to earth via a 100 k Ω resistor.

Whilst it is recommended that the output digital common be referred to true earth, the input terminals may be floated as high as 500 volts relative to true earth and digital common.

The 50-way connector (J5) also provides various control lines and flags, enabling complete external control of the Analogue to Digital converter. All levels are TTL compatible, with a fan-out of 2.

4.2 OPTION B02: THREE-STATE LOGIC OUTPUT (1041 only)

Option B02 is a 3-state (or 'Tri-state'*) version of Option B01. The basic difference is that upon application of a logic low to pin 42, PRINT INHIBIT, all active BCD and control lines are inhibited. The output lines are forced to a 'third' state which is a very high impedance OFF state.

The instrument can therefore be permanently connected to a logic highways or bus-bars in a system and then, by the application of a single logic 0 to pin 42, electrically disconnected at will. Another example would be where the BCD outputs of several instruments are connected in parallel to a printer: a simple single-pole switch could be used to select the outputs from a particular instrument for printing.

4.3 OPTION B04: THREE-STATE LOGIC OUTPUT (1051 only)

On Option B04 a 3-state (or 'Tri-state'*) output is standard, and operates as Option B02 described in Section 4.2.

*Trade mark: National Semiconductor Inc.

4.4 CONNECTIONS

The following table lists the various functions of the pins on connector J5. BCD output numbers are given magnitudes that assume operation in the 1 V range. Bar notation indicates that a low level (less than 0.4 V) is 'active' or 'enables' the described state.

e.g. $\overline{\text{mV}}$ means that pin 32 is low (less than 0.4 V) when the instrument is operating in either of its two permitted millivolt conditions: 10 mV or 100 mV.

Note: Information in brackets indicates present on 1051 only.

J5 Pin No	Function	Description
1	2×10^{-4}	BCD Output No
2	4×10^{-4}	" " "
3	8×10^{-4}	" " "
4	1×10^{-4}	" " "
5	2×10^{-3}	" " "
6	4×10^{-3}	" " "
7	8×10^{-3}	" " "
8	1×10^{-3}	" " "
9	2×10^{-2}	" " "
10	4×10^{-2}	" " "
11	8×10^{-2}	" " "
12	1×10^{-2}	" " "

J5 Pin No.	Function	Description
13	2×10^{-1}	" " "
14	4×10^{-1}	" " "
15	8×10^{-1}	" " "
16	1×10^{-1}	" " "
17	OVERLOAD	Indicates greater signal greater than 19999(9)
18	1×10^0	BCD Output No.
19	(2×10^{-5})	(" " ")
20	(4×10^{-5})	(" " ") 1051
21	(8×10^{-5})	(" " ") only
22	(1×10^{-5})	(" " ")
23	Not used	
24	Not used	
25	$\overline{\text{EXT REF}}$	0 indicates External Reference
26	$\overline{\text{MINUS POLARITY}}$	0 indicates negative reading
27	$\overline{\text{PLUS POLARITY}}$	0 indicates positive reading
28	$\overline{\text{OHMS}}$	0 indicates Resistance Measurement
29	$\overline{\text{DC}}$	0 indicates DC Measurement
30	$\overline{\text{AC}}$	0 indicates AC Measurement
31	$\overline{\text{FILTER}}$	0 indicates FILTER: 1 = NORMAL
32	$\overline{\text{mV}}$	0 indicates mV: 1 indicates Volts
33	$\overline{\text{AUTORANGE}}$	0 indicates AUTO, 1 indicates MANUAL
34	Range A	) for coding
35	Range B	) see Range
36	Range C	) Coding
37	Range D	) Tables.
38	FP CONTROL	Input Control Line
39	Digital COMMON	0 state reference
40	$\overline{\text{HOLD}}$	Input control line
41	$\overline{\text{COMMAND}}$	Input control line
42	$\overline{\text{PRINT INHIBIT}}$	Input control line
43	$\overline{\text{SIG. INTEGRATE}}$	Output control flag
44	$\overline{\text{DELAY}}$	Input control line
45	$\overline{\text{PRINT COMMAND}}$	Output control flag
46	Not used	
47	Not used	
48	Not used	
49	Not used	
50	Not used	

4.4.1 Examples of BCD Coding

Suppose the following pins of J5 are in a 1 state (greater than 2.4V):–

$$3 - 5 - 6 - 9 - 12 - 15 - 16 - (20)$$

this gives a reading of:–

Pins

3	8×10^{-4}	= .0008
5 & 6	$2 \times 10^{-3} + 4 \times 10^{-3}$	= .006
9 & 12	$2 \times 10^{-2} + 1 \times 10^{-2}$	= .03
15 & 16	$8 \times 10^{-1} + 1 \times 10^{-1}$	= .9
(20)	(4×10^{-5})	= (.00004)
	TOTAL	= .9368(4)

This coding of readings is common to 1041 and 1051 models.

1051 Range Coding

The table below shows the state of the RANGE outputs for the six ranges.

Range	Pin 34(A)	Pin 35(B)	Pin 36(C)
10mV	1	0	0
100mV/ Ω	0	1	0
1V/k Ω	1	1	0
10V/k Ω	0	0	1
100V/k Ω	1	0	1
1,000V/k Ω	0	1	1
10,000 k Ω	1	1	1

Now suppose pins 32, 34 and 36 are all in a low or 0 state (less than 0.4V) Pin 32 low, indicates that the instrument is measuring mV. Pins 34 and 36 low, with Pin 35 high, indicates a full range of 100.000 mV. The reading is therefore 93.684 mV.

1041 Range Coding

The table below shows the state of the RANGE outputs for the six ranges, the coding being a decimal point indicator.

Ranges	Pin 34 (A)	Pin 35 (B)	Pin 36 (C)	Pin 37 (D)
10mV/ Ω	1	0	1	1
100mV/ Ω	1	1	0	1
1V/k Ω	0	1	1	1
10V/k Ω	1	0	1	1
100V k Ω	1	1	0	1
1000V/k Ω	1	1	1	0
10,000 k Ω	1	1	1	1

Suppose that, in addition to the BCD coding given in the example, Pins 32 and 35 are both in a low or 0 state (less than 0.4V).

Pin 32 low indicates that the instrument is in a mV range.

Pin 35 low indicates that the BCD coded reading is to be multiplied by 10.

The reading is therefore

$$.9368 \times 10 \text{ millivolts} = 9.368 \text{ millivolts.}$$

1041 and 1051

Pin 31 is merely a flag indicating the filter measurement mode, and does not affect interpretation of the BCD number. Pin 17, OVERLOAD, indicates when the input signal is too high for a particular range. BCD numbers may be present even when Pin 17 is in a 1 state but they must not be taken as valid though they will be accurate for numbers only slightly in excess of 19999(9).

4.4.2 Control Lines

Pins 40 to 45 are control lines, enabling the user to control the instrument remotely when it is used in conjunction with other equipment as part of a test system. The control input lines float to a 1 or high state if open circuit, and can be held to a 0 or low state by connecting them to pin 39, digital COMMON:

4.4.3 Print Command

Pin 45, PRINT COMMAND falls from a 1 to 0 state at the end of each measurement cycle, when the new reading has been transferred to the storage registers and is available at the pins of J5 in the form of steady BCD output information.

The falling voltage step available at pin 45 can thus command an external reading device to take note of the BCD output or, alternatively, the 1 state can be used to inhibit scanning of the BCD information. Since the reading is stored it is available at any time except when new information is being transferred. Pin 45 is only in the 1 state for the duration of the transfer period, lasting about 5 microseconds.

A logic low on pin 42 PRINT INHIBIT prevents the PRINT COMMAND edge from occurring on pin 45, thus making it easy to stop external printers etc. Pin 45 is forced to a low state in this condition.

4.4.4 Signal Integrate

Pin 43 exhibits a high state flag while the analogue to digital converter is acquiring its information. It is made available because its falling edge represents the earliest time at which new signal information may be applied to the input terminals without disturbing the reading in hand. It can thus be used to operate a signal scanner, for example, at the highest possible speed for fully accurate information. The falling edge can also be used to command the instrument, via its delayed command facility, at the same time. See Section 4.4.7.

4.4.5 Hold Reading

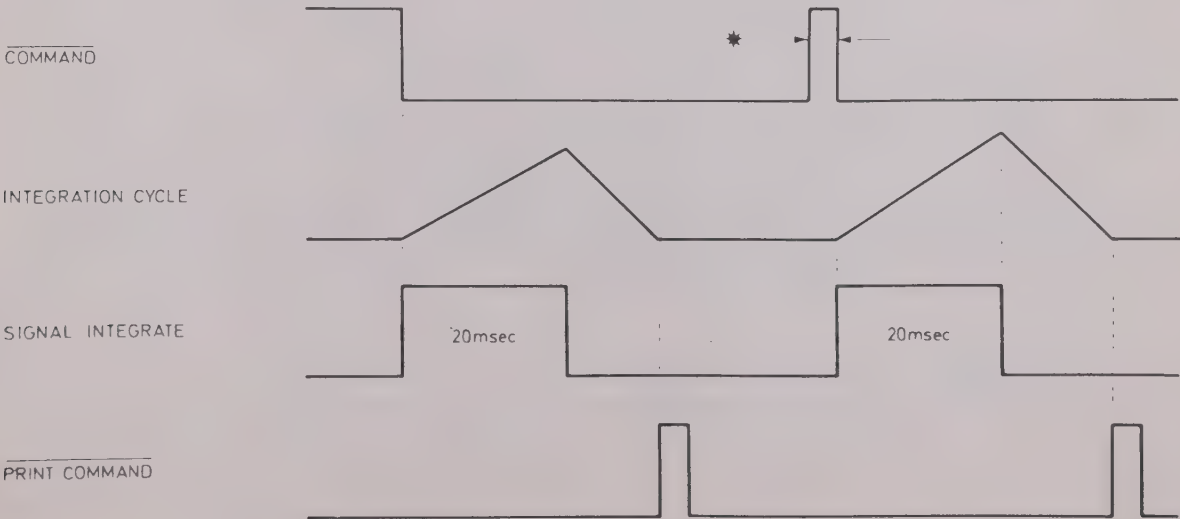
Pin 40, HOLD, may be externally held in a low state if it is desired to stop the instrument from reaching its normal free-run mode. When pin 40 is taken low the instrument will complete any reading in progress, followed by storing and displaying it until pin 40 is taken high or released, or until an external read command is applied.

4.4.6 Read Command

A falling edge on pin 41, COMMAND, instructs the instrument to take one reading immediately if, and only if, pin 40 HOLD is already held low. The instrument inhibits commands that are applied before conversion in progress is complete. Fig. 4.1 shows the relationship of COMMAND and PRINT COMMAND to the integration cycle.

Fig 4.1

NOTE: Minimum COMMAND pulse is 2μS.

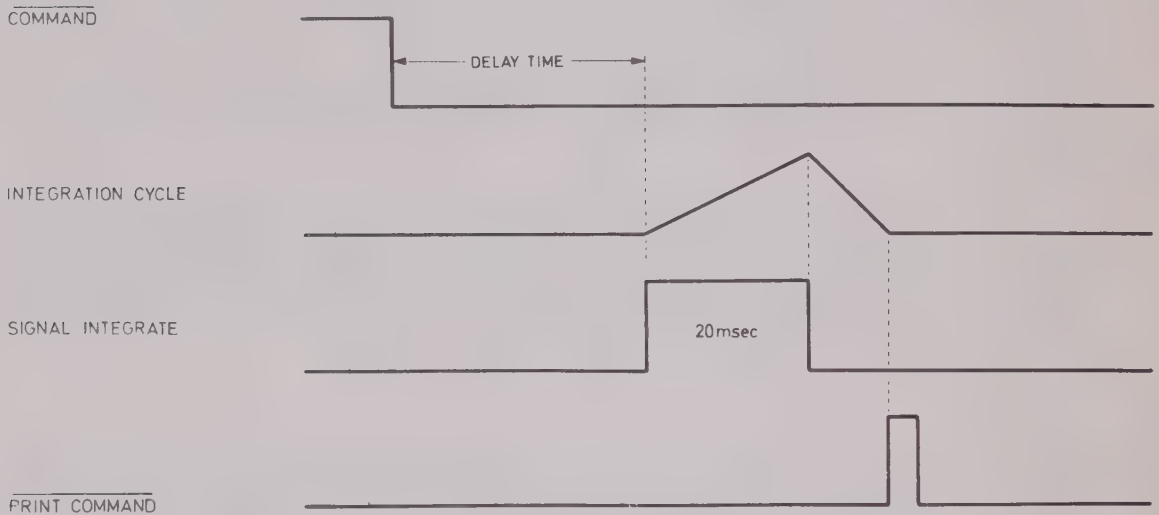


4.4.7 Delayed Command

If pin 44, $\overline{\text{DELAY}}$ is held at logic 0 while an external command is applied, then the command will be automatically delayed by a period of time equal to the settling time of the integration filter. This delay is automatically adjusted depending on whether NORMAL or FILTER is selected by the front panel push button.

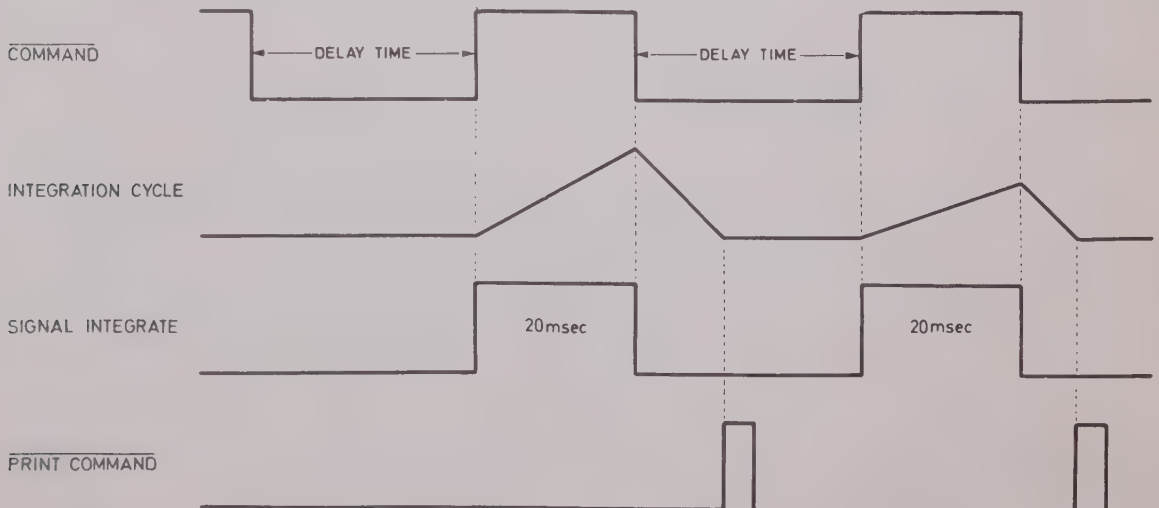
Provided Pin 44 is held low, this means that the instrument can be commanded at the same instant that new signal information is applied to the front panel terminals. A particularly useful example of this is where the instrument is used in conjunction with a signal scanner, the same command being used for stepping or switching the scanner, as for commanding a reading to be taken, see Fig. 4.2.

Fig. 4.2



For maximum read rate in a closed-loop system, the command could be the falling edge of pin 43, SIGNAL INTEGRATE, see Fig. 4.3.

Fig. 4.3



4.4.8 0 State Reference

All digital outputs and command lines are referred to digital COMMON on pin 39. Maximum fan-in is one TTL load, minimum fan-out is 2 TTL loads.

4.4.9 FP Control

If pin 38 is held low the front panel control push buttons are inhibited, i.e. PRINT INHIBIT, MANUAL and HOLD.

4.5 P01: REMOTE PROGRAMMING

4.5.1 Description

Option P01 enables all ranges and functions on the instrument to be remotely programmed via the 14-way Amphenol, rear panel mounted connector. All the programme lines are electrically isolated from the signal input terminals via opto-electronic isolators. Programme common (digital common) may be floated to a different potential from earth but is internally referenced to earth via a 100k resistor. It is therefore recommended that programme common be referred to earth in the measurement system; the signal input terminals are then able to float ± 500 volts peak relative to earth and digital common.

4.5.2 Range Connections

The table below shows the required states to programme the seven ranges. Note that the 10 Megohm range is, of course, only valid if ohms is also selected otherwise it behaves as a 1kV range except for the decimal point position.

Pin No	8	9	10	11	12
Range					
10mV/ Ω	1	0	0	0	0
100mV/ Ω	0	1	0	0	0
1V/k Ω	1	1	0	0	0
10V/k Ω	0	0	1	0	0
100V/k Ω	1	0	1	0	0
1000V/k Ω	0	1	1	0	0
10,000k Ω	1	1	1	0	0
AUTO	X	X	X	1	0

Note that AUTO overrides any range selection made and thus AUTO must be programmed to permit any particular range to be selected and, of course, REMOTE must be commanded either at the front panel or via the programme connector as described.

4.5.3 Function Connections

In this table the function codes are given. They are definitive except for FILTER which may be selected or not whatever other function has been. This is denoted by X.

Pin No	1	3	5	7	12
Function					
DC VOLTS	X	1	1	X	0
AC VOLTS	X	0	1	X	0
RESISTANCE	X	1	0	X	0
FILTER	1	X	X	X	0
NORMAL ($\overline{\text{FILTER}}$)	0	X	X	X	0
RATIO (Ext. Reference)	X	X	X	0	X

4.5.4 Characteristics of Use

With no connection the programme lines float to a “1” state and normally if programme is enabled by REMOTE, then the instrument will relax to the safe condition of AUTO, DC VOLTS.

The tables in sections 4.5.2 and 4.5.3 must be adhered to if sensible results are to be obtained but damage is unlikely to occur if forbidden codes are programmed.

Programme logic levels are TTL compatible with a fan-in no greater than one TTL load. A “0” state should be no greater than .4 volts relative to Programme Common (Pin 2) and a “1” state no less than 2.4 volts.

Programme lines are not protected against over voltage transients and therefore great care should be taken to ensure that no spikes, even of very short duration, exceed 5 volts relative to pin 2, programme common.

4.5.5 Other Options

Other programme and BCD output options are available to special order. In general interfacing the 1041 or 1051 with a system designed for another voltmeter is not difficult. Do not hesitate to consult the factory for advice.

SECTION 5

OTHER OPTIONS

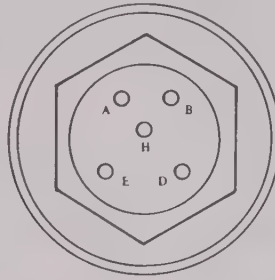
5.1 ANALOGUE O/P

The analogue output is presented from the rear panel via a 5-pin M series connector. A fast-acting fuse is included in both the Hi and Lo side. It is a 1V full range output for any nominal full range input, with overrange capability to 2V. The output impedance is in the order of a few ohms and no more than 5mA should be demanded.

Pin connections as seen from rear.

A = Output Hi

B = Output Low



5.2 REAR INPUT R01

Occasionally it may be more convenient for a user to apply his signal input via the rear rather than the front panel.

Pin connections as seen from rear.

A = Ω Guard

B = Not used

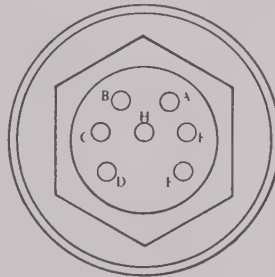
C = I+

D = Input Hi

E = Input Lo

F = I

H = Guard



A 7 pin M series connector is provided, and should be carefully wired since a high voltage may be present.

When using rear inputs care should be taken as the input voltage will still be present at the front panel terminals. This could be hazardous.

5.3 EXTERNAL REFERENCE (RATIO)

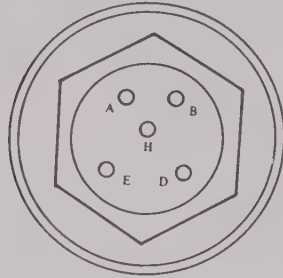
Two ratio options are available:

1V range, R02 for 1041 and R03 for 1051.

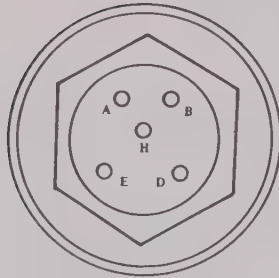
10V/100V range, R05 for 1041 and R06 for 1051.

The reference buffer or ratio option is a 4 wire precision isolation buffer which scales the external reference signal and drives the reference circuitry of the analogue to digital converter in place of the internal reference. Although on 1041 the reference input can only be positive it can normally perform ratio measurements with negative reference signals simply because it is floating from the main signal input terminals and can thus be connected “backwards”. For 1051 the reference input may be of either polarity as internal circuitry senses the polarity of both the signal and reference inputs and enables 4 quadrant ratio measurements to be made.

Pin connections as seen from rear.



- A = Not used
- B = Not used
- H = Signal Lo
- E = Input Hi (1V)
- D = Input Lo (1V)



- A = Input Hi (10V)
- B = Input Lo (10V)
- H = Signal Lo
- E = Input Hi (100V)
- D = Input Lo (100V)

SECTION 6

SPECIFICATION VERIFICATION

6.1 DESCRIPTION

The following steps form a routine for checking that the instrument is working within its specified accuracy where the intention is not to re-calibrate internally. It is thus useful for incoming inspection or routine calibration checks.

It is recommended that due to the wide measurement capability of the instrument, only those aspects of the specification relevant to normal use be verified. This saves considerably in both time and calibration equipment, especially where the $1\mu\text{V}$ resolution or hf AC performance are not required. For general-purpose measurements, the whole procedure should be followed to verify the entire specification. Space is provided to tick against each step checked.

6.2 INSTRUMENT REQUIREMENTS (DC) 1041

A DC source is required of accuracy at least three times better than the accuracy being verified, from 10mV to 1000V.

Examples-

Julie Research DVS 106

Optimation AC 126/PA226 (For AC and DC)

6.3 PROCEDURE – DC PERFORMANCE 1041

6.3.1 Turn on the instrument to be checked and allow at least one hour, preferably two hours, to warm up.

6.3.2 Switch instrument to 1 volt range. Flick the Local/Remote Guard switch to LOCAL.

6.3.3 Connect Hi to Lo with a short link. Check the instrument reads $.0000 \pm .0001\text{V}$

6.3.4 Apply +1.0000 volts check reading is
 $+1.0000 \pm .0002\text{V}$

6.3.5 Apply –1.0000 volts check reading is
 $-1.0000 \pm .0002\text{V}$

If 6.3.3 to 6.3.5 are passed this indicates that most of the instrument is working correctly. If it is failed by more than 0.3% then it is likely that there is a fault rather than a calibration error.

6.3.6 Select 10V range

Apply +10.000V check reading is
 $+10.000 \pm .0002\text{V}$

6.3.7 Apply –10.000V Check reading is
 $-10.000 \pm .0002\text{V}$

6.3.8 Select 100V range

Apply +100.00V check reading is
 $+100.00 \pm .02\text{V}$

6.3.9 Apply —100.00V check reading is
—100.00 ± .02V

6.3.10 Select 1kV range

Apply +1000.0V check reading is
+1000.0 ± 0.2V

6.3.11 Apply —1000.0V check reading is
—1000.0 ± 0.2V

6.3.12 Select 10mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of ± 0.000 mV

Apply +10.000 mV, check reading is
+10.000 ± 0.003 mV

6.3.13 Apply —10.000 mV, check reading is
—10.000 ± 0.003 mV

(If changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible, reverse polarity at a higher voltage level so as not to reverse thermals).

6.3.14 Select 100 mV range

Apply +100.00 mV, check reading is
+100.00 ± 0.02 mV

6.3.15 Apply —100.00 mV, check reading is
—100.00 ± 0.02 mV

This concludes checking of accuracy.

6.3.16 For linearity check, select 1 volt range.

Apply +0.1000V, check reading is
+0.100V ± 0.001V

6.3.17 Apply +0.5000V, check reading is
+0.5000 ± 0.00015V

6.3.18 Apply +1.000V, check reading is
+1.000 ± .0002V

6.3.19 Apply +1.9000V, check reading is
+1.9000 ± .0003V

DC Verification is now complete.

6.4 INSTRUMENT REQUIREMENTS (AC) 1041

Optimation AC125/PA225

Hewlett Packard 745/746

Optimation AC126/PA226 (AC and DC)

6.5 PROCEDURE AC PERFORMANCE 1041

6.5.1 Carry out 6.3.1 and 6.3.2 and switch to FILTER

6.5.2 Connect Hi to Lo with a short link. Check instrument reads .0003 maximum.

6.5.3 The check readings in the following list will have two limits. The first is for the model 01, the second of wider limits the model 11.

6.5.4 Apply 1.0000 volts at 5 kHz, 20 kHz, 100 kHz in turn. The readings are respectively:

$$1.0000 \pm .0005 (.0014) \text{ V}$$

$$1.0000 \pm .0010 (.0030) \text{ V}$$

$$1.0000 \pm .0020 (.0050) \text{ V}$$

If this test is failed by more than about .3% at 5 kHz or 2% at 100 kHz there is probably a fault rather than a calibration error.

6.5.5 Repeat 6.5.4 for the 10V range with 10V input. The readings are:

$$10.000 \pm .005 (.014) \text{ V}$$

$$10.000 \pm .010 (.030) \text{ V}$$

$$10.000 \pm .020 (.050) \text{ V}$$

6.5.6 Repeat 6.5.4 for the 100V range with 100V input. The readings are:

$$100.00 \pm .05 (.14) \text{ V}$$

$$100.00 \pm .10 (.30) \text{ V}$$

$$100.00 \pm .20 (.50) \text{ V}$$

6.5.7 Repeat 6.5.4 for the 1000 V range with 1000 V input except at 100 kHz which is not specified. The readings are:

$$1000.0 \pm 1.2 (1.4) \text{ V}$$

$$1000.0 \pm 1.7 (3.0) \text{ V}$$

At 300 V the readings should be:

$$300.0 \pm .3 (.7) \text{ V}$$

$$300.0 \pm .6 (1.6) \text{ V}$$

6.5.8 The remaining steps do not apply to the type 11 converter.

6.5.9 Repeat 6.5.4 for the 10 mV range with 10 mV applied. 100 kHz is not applicable to this range. The readings are:

$$10.000 \pm .020 \text{ mV}$$

$$10.000 \pm .030 \text{ mV}$$

6.5.10 Repeat 6.5.4 for the 100 mV range with 100 mV applied. The readings are:

$$100.00 \pm .05 \text{ mV}$$

$$100.00 \pm .10 \text{ mV}$$

$$100.00 \pm .20 \text{ mV}$$

AC verification is now complete.

6.6 INSTRUMENT REQUIREMENTS (OHMS) 1041

A set of standard resistors is required covering 10 Ω to 10 M Ω . The 10 Ω and 100 Ω resistors should be 4-wire types.

6.7 PROCEDURE – OHMS PERFORMANCE 1041

6.7.1 Carry out steps 6.3.1 and 6.3.2.

- 6.7.2** Select 10 Ω , 4-wire: connect the 10 Ω resistor in a 4 terminal measurement.

Check instrument reading is:

$$10.000 \pm .003\Omega$$

- 6.7.3** Select 100 Ω , 4-wire, connect the 100 Ω resistor in a 4 terminal measurement. Check reading is:

$$100.00 \pm .02\Omega$$

- 6.7.4** Select 1k Ω , 4-wire. Connect the 1k Ω resistor for 4-wire. Reading is:

$$1.000 \pm .0002 \text{ k}\Omega$$

- 6.7.5** Select 10 k Ω , 2-wire. Connect the 10k Ω resistor to Hi and Lo. Reading is:

$$10.000 \pm .002 \text{ k}\Omega$$

- 6.7.6** Select 100 k Ω , 2-wire. Connect the 100k Ω resistor to Hi and Lo. Reading is:

$$100.00 \pm .02 \text{ k}\Omega$$

- 6.7.7** Select 1M Ω , 2-wire. Connect the 1M Ω resistor to Hi and Lo. Reading is:

$$1000.0 \pm .3 \text{ k}\Omega$$

- 6.7.8** Select 10M Ω , 2-wire. Connect the 10M Ω resistor to Hi and Lo. Reading is:

$$10000 \pm 11 \text{ k}\Omega$$

If long unscreened leads are used on the last two measurements, the use of FILTER will reduce the digit jitter, due to 50 Hz pick-up.

If high value standard resistors have a guard terminal then connect this to ohms guard.

If all the checks made in Section 6.7 are made, and met, this confirms that the model 1041 is within its calibration specification for resistance.

6.8 INSTRUMENT REQUIREMENTS (EXTERNAL REFERENCE) R02 – 1041

A stable DC source of approximately 1V and .2V.

6.9 PROCEDURE EXTERNAL REFERENCE R02 – 1041

Make sure that the DC signal measurement is working correctly as in Section 6.3. Switch the rear panel slide switch to external reference.

- 6.9.1** Connect Signal Hi to Reference Hi and Signal Lo to Reference Lo. Switch Guard to Local, and to 1V range. Apply approximately +1V to the commoned signal and reference inputs. The reading is:

$$1.0000 \pm .0002$$

- 6.9.2** Repeat 6.9.1 with +0.2 volts. The reading is:

$$1.0000 \pm .0006$$

If these conditions are met then the external reference performance is functioning correctly.

6.10 INSTRUMENT REQUIREMENTS (EXTERNAL REFERENCE) R05 – 1041

A stable source of approximately 10V and 100V, 2V and 20V.

6.11 PROCEDURE EXTERNAL REFERENCE R05 – 1041

Make sure the DC signal measurement is working correctly as in Section 6.3. Switch the rear panel slide switch to external reference.

- 6.11.1 Connect Signal Hi to 10V reference Hi and signal Lo to 10V reference Lo. Switch guard to local and to 10V range. Apply approximately 10V to the commoned inputs. Check that the reading is:

$$10.000 \pm .002$$

- 6.11.2 Repeat 6.11.1 with 2V, check that reading is:

$$10.000 \pm .006$$

- 6.11.3 Connect Signal Hi to 100V reference Hi and Signal Lo to 100V reference Lo. Switch to 100V range. Apply approximately 100V to the commoned inputs, check that the reading is:

$$100.00 \pm .02$$

- 6.11.4 Repeat 6.11.3 with approximately 20V, check that reading is:

$$100.00 \pm .06$$

6.12 INSTRUMENT REQUIREMENTS (DC) 1051

A DC source is required of accuracy at least three times better than the accuracy being verified, from 10mV to 1000V.

Examples:

Julie Research DVS 106

Fluke 332D

Precision Attenuator for low voltages.

6.13 PROCEDURE – DC PERFORMANCE 1051

- 6.13.1 Turn on the instrument to be checked and allow at least one hour, preferably two hours, to warm up.

- 6.13.2 Switch instrument to 1 volt range. Flick the Local/Remote Guard switch to LOCAL.

- 6.13.3 Connect Hi to Lo with a short link. Check the instrument reads $.00000 \pm .00001$ V

- 6.13.4 Apply +1.00000 volts check reading is
 $+1.00000 \pm .00005$ V

- 6.13.5 Apply -1.00000 volts check reading is
 $-1.00000 \pm .00005$ V

If 6.13.3 to 6.13.5 are passed this indicates that most of the instrument is working correctly. If it is failed by more than 0.3% then it is likely that there is a fault rather than a calibration error.

- 6.13.6 Select 10V range

Apply +10.0000 V check reading is
 $+10.0000 \pm .0005$ V

- 6.13.7 Apply -10.0000 V check reading is
 $-10.0000 \pm .0005$ V

- 6.13.8 Select 100V range

Apply +100.000 V check reading is
 $+100.000 \pm .005$ V

6.13.9 Apply -100.000 V , check reading is
 $-100.000 \pm .005\text{ V}$

6.13.10 Select 1kV range

Apply $+1000.00\text{ V}$ check reading is
 $+1000.00 \pm .05\text{ V}$

6.13.11 Apply -1000.00 V check reading is
 $-1000.00 \pm .05\text{ V}$

6.13.12 Select 10mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of $\pm 0.000\text{ mV}$

Apply $+10.0000\text{ mV}$ check reading is
 $+10.0000 \pm .0015\text{ mV}$

6.13.13 Apply -10.0000 mV , check reading is
 $-10.0000 \pm .0015\text{ mV}$

(If changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible reverse polarity at a higher voltage level so as not to reverse thermals).

6.13.14 Select 100 mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of $\pm 0.0000\text{ mV}$

Apply $+100.000\text{ mV}$, check reading is
 $+100.000 \pm .006\text{ mV}$

6.13.15 Apply -100.000 mV , check reading is
 $-100.000 \pm .006\text{ mV}$

(If changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible reverse polarity at a higher voltage level so as not to reverse thermals).

This concludes checking of accuracy.

6.13.16 For linearity check, select 1 volt range.

Apply $+0.10000\text{ V}$ check reading is
 $+0.10000 \pm .00001\text{ V}$

6.13.17 Apply $+0.50000\text{ V}$, check reading is
 $+0.50000 \pm .00003\text{ V}$

6.13.18 Apply $+1.00000\text{ V}$, check reading is
 $+1.00000 \pm .00005\text{ V}$

6.13.19 Apply $+1.90000\text{ V}$, check reading is
 $+1.90000 \pm .00009\text{ V}$

DC Verification is now complete.

6.14 INSTRUMENT REQUIREMENTS (AC) 1051

Optimization AC125/PA225

Hewlett Packard 745/746

Optimization AC126/PA226 (AC and DC)

6.15 PROCEDURE AC PERFORMANCE 1051

6.15.1 Carry out 6.13.1 and 6.13.2 and switch to FILTER

6.15.2 Connect Hi to Lo with a short link. Check instrument reads .00030 maximum.

6.15.3 The check readings in the following list will have two limits. The first is for the model 01, the second of wider limits the model 11.

6.15.4 Apply 1.0000 volts at 5 kHz, 20 kHz, 100 kHz in turn. The readings are respectively:

.1.00000 $\pm$.00050 (.00140)V

1.00000 $\pm$.00100 (.00300)V

1.00000 $\pm$.00200 (.00500)V

If this test is failed by more than about .3% at 5 kHz or 2% at 100 kHz there is probably a fault rather than a calibration error.

6.15.5 Repeat 6.15.4 for the 10V range with 10V input. The readings are:

10.0000 $\pm$.0050 (.0140)V

10.0000 $\pm$.0100 (.0300)V

10.0000 $\pm$.0200 (.0500)V

6.15.6 Repeat 6.15.4 for the 100V range with 100V input. The readings are:

100.000 $\pm$.050 (.140)V

100.000 $\pm$.100 (.300)V

100.000 $\pm$.200 (.500)V

6.15.7 Repeat 6.15.4 for the 1000V range with 1000V input except at 100 kHz which is not specified. The readings are:

1000.00 $\pm$ 1.20 (1.40) V

1000.00 $\pm$ 1.70 (3.00) V

At 300V the readings should be:

300.00 $\pm$.30 (.70) V

300.00 $\pm$.60 (1.60) V

6.15.8 The remaining steps do not apply to the type 11 converter.

6.15.9 Repeat 6.15.4 for the 100 mV range with 100 mV applied. The readings are:

100.000 $\pm$.050 mV

100.000 $\pm$.100 mV

100.000 $\pm$.200 mV

AC verification is now complete.

6.16 INSTRUMENT REQUIREMENTS (OHMS) 1051

A set of standard resistors is required covering 100 Ω to 10M Ω . The 100 Ω resistor should be 4-wire type.

6.17 PROCEDURE – OHMS PERFORMANCE 1051

6.17.1 Carry out steps 6.13.1 and 6.13.2.

6.17.2 Select 100 Ω , 4-wire, connect the 100 Ω resistor in a 4 terminal measurement. Check reading is:

100.000 $\pm$.007 Ω

- 6.17.3** Select 1k Ω , 4-wire, connect the 1k Ω resistor for 4-wire. Reading is:

1.00000 $\pm$.00007 k Ω

- 6.17.4** Select 10k Ω , 2-wire. Connect the 10k Ω resistor to Hi and Lo. Reading is:

10.0000 $\pm$.0007 k Ω

- 6.17.5** Select 100k Ω , 2-wire. Connect the 100k Ω resistor to Hi and Lo. Reading is:

100.000 $\pm$.007 k Ω

- 6.17.6** Select 1M Ω , 2-wire. Connect the 1M Ω resistor to Hi and Lo. Reading is:

1000.00 $\pm$.22 k Ω

- 6.17.7.** Select 10M Ω , 2-wire. Connect the 10M Ω resistor to Hi and Lo. Reading is:

10.0000 $\pm$.0102 M Ω

If long unscreened leads are used on the last two measurements, the use of FILTER will reduce the digit jitter, due to 50 Hz pick-up.

If high value standard resistors have a guard terminal then connect this to ohms guard.

If all the checks made in Section 6.17 are made, and met, this confirms that the model 1051 is within its calibration specification for resistance.

6.18 INSTRUMENT REQUIREMENTS (EXTERNAL REFERENCE) R03 – 1051

A stable DC source of approximately 2V and .3V.

6.19 PROCEDURE EXTERNAL REFERENCE R03 – 1051

Make sure that the DC signal measurement is working correctly as in Section 6.13. Switch the rear panel slide switch to external reference.

- 6.19.1** Connect Signal Hi to Reference Hi and Signal Lo to Reference Lo. Switch Guard to Local, and to 1V range apply approximately +2V to the commoned signal and reference inputs. The reading is:

1.00000 $\pm$.00006

- 6.19.2** Repeat 6.19.1 with +0.3 volts. The reading is:

1.00000 $\pm$.00011

If these conditions are met then the external reference performance is functioning correctly.

6.20 INSTRUMENT REQUIREMENTS (EXTERNAL REFERENCE) R06 – 1051

A stable source of approximately 20V and 200V, 3V and 30V.

6.21 PROCEDURE EXTERNAL REFERENCE R06 – 1051

Make sure the DC signal measurement is working correctly as in Section 6.13. Switch the rear panel slide switch to external reference.

- 6.21.1** Connect Signal Hi to 10V reference Hi and Signal Lo to 10V reference Lo. Switch Guard to Local and to 10V range. Apply approximately 20V to the commoned inputs. Check that the reading is:

10.0000 $\pm$.0007

6.21.2 Repeat 6.21.1 with 3V, check that reading is:

$10.0000 \pm .0018$

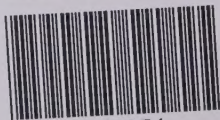
6.21.3 Connect Signal Hi to 100V reference Hi and Signal Lo to 100V reference Lo. Switch to 100V range. Apply approximately 200V to the commoned inputs, check that the reading is:

$100.000 \pm .007$

6.21.4 Repeat 6.21.3 with approximately 30V, check that reading is:

$100.000 \pm .018$

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